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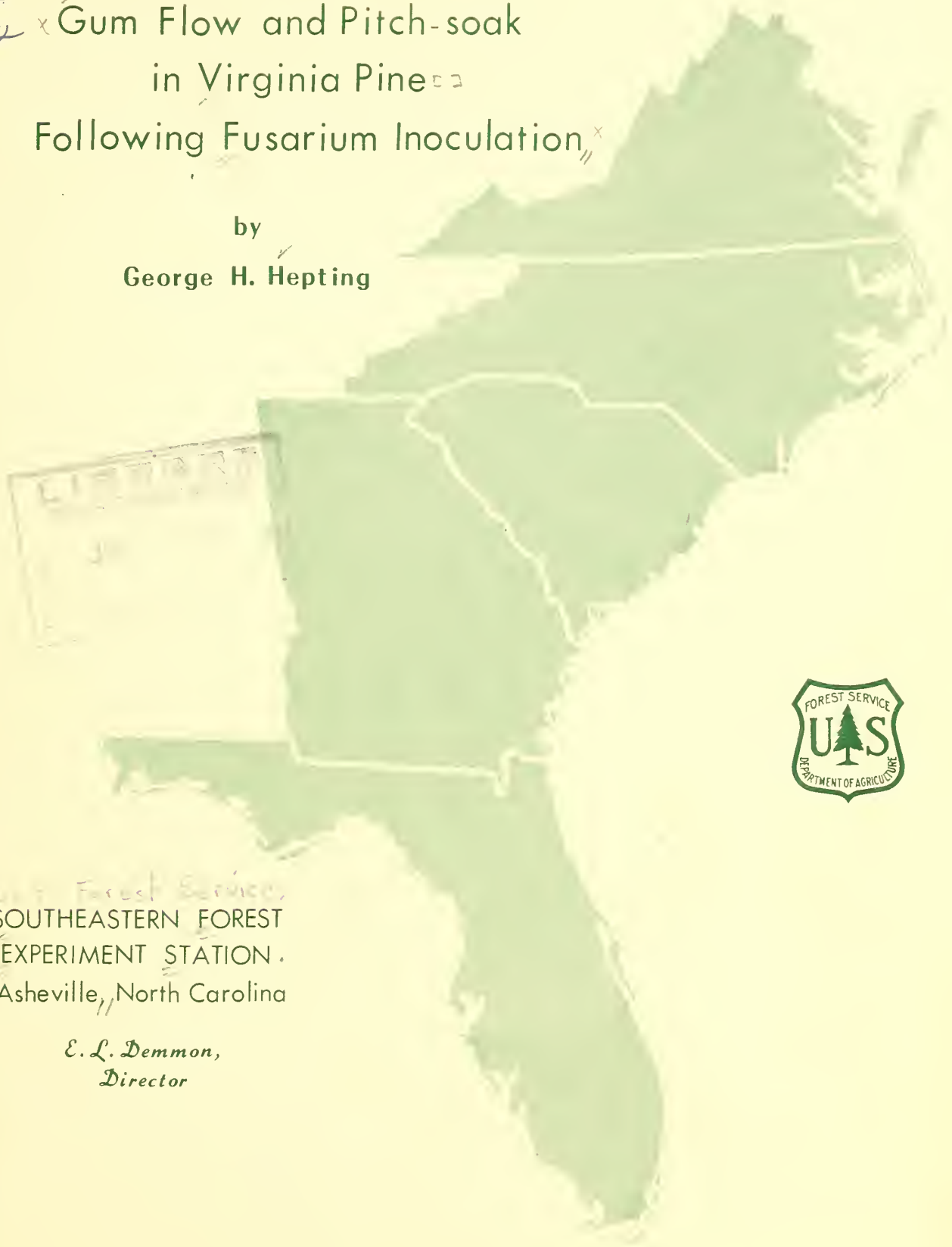

SOUTHEASTERN FOREST
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GUM FLOW AND PITCH-SOAK IN VIRGINIA PINE FOLLOWING FUSARIUM INOCULATION

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In 1947 (4) the author reported on the capacity of a Fusarium later named F. lateritium Nees em. S. and H. f. pini Hept. (7) to prolong the flow of oleoresin from wounds in three species of southern pine. True and Snow (8) later conducted experiments to determine whether this characteristic of the fungus could be put to commercial use on slash and longleaf pine in turpentining operations. Clapper (2) continued the work started by True and Snow at Lake City, Florida. F. lateritium f. pini was originally described as the cause of the pitch-canker disease, first on Virginia pine (3) and later on a number of other hard pines (5).

True and Snow and also Clapper concluded that spore suspensions of the Fusarium sprayed on slash and longleaf pine induced a temporary stimulation of gum flow, which on virgin streaks often lasted several weeks. But season-long yields involving rechipping and applying the fungus every 2 to 5 weeks on a variety of chipping schedules did not give gum yields as large or as consistent as yields from streaks sprayed with sulfuric acid (2, 8). Commercial use of the fungus method, therefore, has not been and is not being recommended.

At least part of the ultimate drop in yield from fungus-treated faces may be due to pitch-soaking of the wood. Whereas the depth of pitch-soak behind untreated slash or longleaf faces is usually only 0.1 or 0.2 inch, the average depth behind fungus faces is often 0.5 inch or more. This pitch infiltration of the wood following application of the fungus has led to research that is still continuing on the use of the Fusarium to induce pitch-soak of living trees for possible use for wood naval stores, fence posts, or other products.

The action of Fusarium lateritium f. pini on Virginia pine is somewhat different from its action on slash and longleaf pine. On the latter two species, the fungus girdles small twigs, leaders, and branches readily, and occasionally has been observed to girdle stems up to about 5 inches in diameter. On larger slash and longleaf stems the fungus spreads tangentially in the bark and wood with difficulty, and when introduced in turpentining wounds spreads very little tangentially. On Virginia pine, however, tangential spread usually continues, regardless of stem diameter, until the stem

is girdled--a process that may take 10 or more years on Virginia pines over 6 inches in diameter (fig. 1). Cambial killing upward and downward from the inoculated streaks reported on herein was at a rate of about 3 to 5 inches in each direction per year.

Figure 1.--A natural pitch canker infection on Virginia pine.

Gum Yields from Inoculated Virginia Pines

Since Virginia pine is so reactive to the pitch canker Fusarium, experiments were run to determine the gum yield and amount of pitch-rich wood produced following the application of spore suspensions of the fungus to turpentining streaks. The method of preparation and application of the spore suspensions has already been described (8).

Table 1 summarizes the data on gum yield in experiments at Bent Creek, near Asheville, North Carolina, at Lenoir, North Carolina, and at Clemson, South Carolina. The first small-scale test was started at Bent Creek. Seven trees were given a single chipping in July 1947, with a standard 1/2-inch wood hack, the wood extending around one-half the circumference of each tree. A fresh spore suspension of Fusarium lateritium f. pini was atomized on the streaks. While these seven trees received only one streak per year, two other trees were wood-chipped once a week for 32 weeks during the same season, and nothing was applied to their streaks. The first-year yield of gum per tree from the single "fungus" streak exceeded the yield from the 32 untreated streaks (table 1). During each of the next 3 years the "fungus" trees were given a new streak above the area killed by the fungus. The untreated trees were no longer worked. Over a 4-year period the "fungus" trees produced 2,445 grams of gum and 713 grams of scrape[1/] per tree, or at a rate of 1.7 pounds per tree per year. This is a small amount, but cheaply obtained from one streak per season, compared to the 8 to 9 pounds per year obtained in chipping slash and longleaf biweekly and using acid on the streaks.

1/ Scrape is a portion of the total yield which hardens on the face and does not flow down into the container.

Table 1.--Gum yields from Virginia pine

Location and treatment	Trees	Streaks per season	Yield per tree							Years
			1947	1948	1949		1950		Total	
			Gum	Gum	Gum	Scrape	Gum	Scrape		
	Number	Number	Grams	Grams	Grams	Grams	Grams	Grams	Grams	
Bent Creek, North Carolina										
No treatment, 1/2-circumference faces	2	32	526	--	--	--	--	--	526	1
Fungus, 1/2 " "	7	1	770	839	611	486	225	227	3,158	4
Lenoir, North Carolina										
Fungus, two 1/3-circumference faces	50	1	--	--	586	--	300	250	1,136	2
Clemson, South Carolina										
No treatment, 1/3-circumference faces	10	32		787	592				1,379	2
Acid, 1/3 " "	10	16		550					550	1
Fungus, 1/3 " "	20	1		440	259		144	141	984	3
" 2/3 " "	20	1		634	284		173	139	1,230	3
" two 1/3 " "	20	1		740	406		214	210	1,570	3

An enlarged experiment was laid out in April 1948 at Clemson, South Carolina. Ten trees were wood-chipped weekly but not treated; 10 were bark-chipped biweekly and 40-percent sulfuric acid sprayed on each streak; 20 were given bark streaks one-third of the way around the circumference and the streaks received an atomized spore suspension; 20 received streaks two-thirds around the circumference and were inoculated, and 20 received two 1/3-circumference, inoculated streaks, one on each side, and one a few inches higher than the other. The trees were so distributed by treatments that essentially the same diameter range (approximately 7 to 12 inches d.b.h.) was represented by each treatment.

In April 1949 the fungus faces were rechipped once into bright bark beyond the killed cambium, the untreated faces were again chipped 32 times during the season, and the acid treatment was dropped. At the end of 1949 the scrape was collected, and in April 1950 the fungus faces received a third annual chipping and were scraped at the end of the season. The mean annual yield of gum for the fungus faces after 3 years, including scrape, was 0.7 pound for the 1/3-circumference trees, 0.9 pound for the 2/3-circumference trees, and 1.2 pounds for the trees with two 1/3-circumference faces (figures 2 and 3).

There was a very wide range in gum yield per tree. At Lenoir, each tree was given a wood-chipping on one side (1/2 inch deep) and a bark-chipping on the other. There was no significant difference between the yields from the fungus on bark streaks and yields from fungus on wood streaks.

In table 2, comparisons are made between the season-long yields for the highest-yielding tree at each locality and the mean of the other comparably treated trees. For the Lenoir and Clemson high-yielding trees, the yields from both faces of these 2-faced trees were very similar, indicating that the trees were truly high-yielders. This confirms the experience with high-yielding lines of slash and longleaf pine (6), and supports the view that this factor is of genetic origin.

Figure 2.--Virginia pine given 16 standard weekly streaks 1/2 inch in width and depth and wood chipped. The 16 streaks yielded 1.3 pounds of gum (in cylinder).

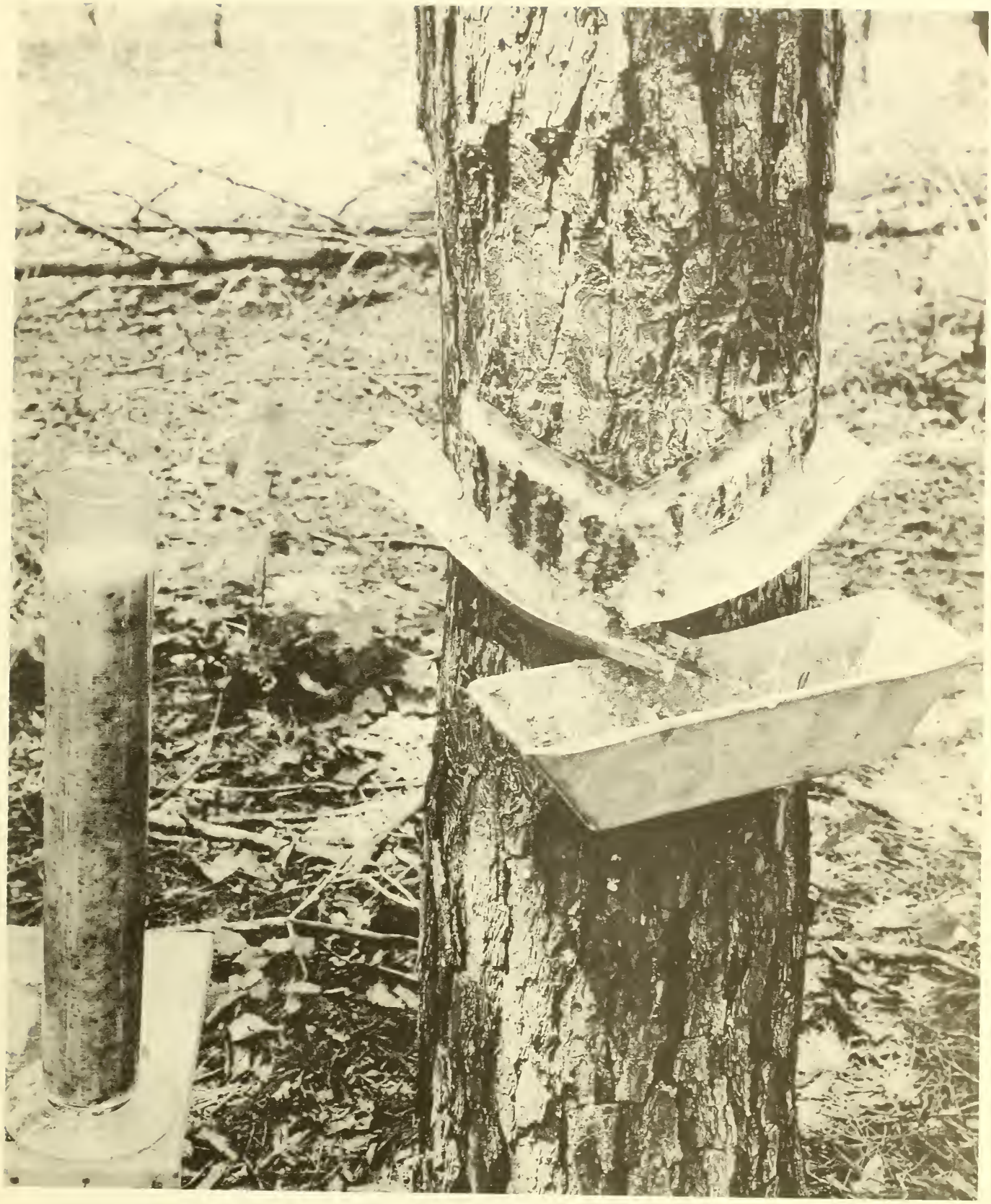

Figure 3.--Virginia pine given only one streak, 1/2 inch in width and depth, upon which a spore suspension of the Fusarium was sprayed. At the end of 16 weeks the tree had yielded 2.4 pounds of gum, as shown in the glass cylinder.

After 1949, the Clemson trees were left without further treatments until the summer of 1952, when they were cut. At that time, the single fungus faces, including the three streaks and killed cambium above and below the streaks, were an average of 14 inches long. There had been an average tangential spread of the fungus of approximately 1 inch from each edge of the original streak and some of the 2-faced trees were completely girdled and dying.

Table 2.--Highest season-long individual tree yields compared with average yields of other trees

Place and year	Trees	D.b.h.	Faces	Weeks per season	Average weekly yield
		Inches	Number	Number	Grams
Clemson, 1948	Best 1	11.3	2	32	58
	Other 19	8.9	2	32	21
Bent Creek, 1949	Best 1	9.9	1	34	75
	Other 6	8.9	1	34	13
Lenoir, 1950	Best 1	9.2	2	27	94
	Other 49	9.1	2	27	11

Pitch-Soak Following Inoculation of Streaks

The pitch-canker Fusarium, whether introduced by inoculation or natural means, typically causes prolonged gum flow and also causes gum to be deposited in the wood. This deposition is practically confined to wood invaded by the fungus. If a complete cross section is made through the trunk behind an inoculated area and a sector of gum-infiltrated wood disclosed, the fungus can usually be isolated readily from the pitch-soaked area, but almost never from the normal-appearing wood. Pitch-soaking of wood behind cankers or inoculated streaks in Virginia pine will usually extend to a depth of 1 inch or more and often to the pith or the heartwood. Vertically, fungus infection and concomitant obvious pitch-soaking of wood extended from 3.5 to 4.0 inches below and 2.5 to 3.5 inches above the extremity of cambium killing in the Clemson inoculated trees.

In 1952, after 3 years of working the fungus faces and 2 years of rest, a bolt was cut from each tree at Clemson, just long enough to include the face and a few inches beyond. These bolts were shipped to the Hercules Powder Company for analysis of the amount of pitch-soaking of the wood. The amount of oil-free oleoresin, referred to as crude rosin (benzene extractive), in these bolts was determined under the supervision of Perry B. Holliman.

All the cross-section analyses, except the untreated controls, were made with the bark included. These analyses represent the faced length of the bolts (table 3). The highest rosin contents obtained are considerably lower than the rosin content of present commercially acceptable wood. Longleaf stumpwood now used for wood naval stores extraction contains well over 500 pounds of rosin per ton of dry wood.

Table 3.--Pitch-soaking of wood behind faces, Clemson, S. C.

Treatment and section analyzed	Bolt			Crude rosin, dry-weight basis	
	Diameter	Length	Weight[1]		
	Inches	Inches	Pounds	Percent	Pounds per ton
Control[2]	9.7	29.5	79		
Bolt half without face				2.9	57
Entire bolt				6.4	127
Acid[3]	9.2	--	--		
Entire cross-section of treated area				7.5	153
Fungus					
1/3-circumference[4]	9.1	12.8	26		
Bolt half with fungus face				19.5	390
Entire bolt				12.9	258
2/3-circumference[5]	8.4	14.0	26		
Bolt section with fungus face				20.0	402
Entire bolt				16.3	331
Two 1/3-circumference faces[6]	8.7	23.8	49		
Section with 2 opposite faces				18.9	379
Entire bolt				16.0	324

1/ At approximately 25-percent moisture content.
2/ 32 streaks per year for 2 years, and 3 years' rest.
3/ 16 " " " , acid-treated for 1 year, then 1 inoculated streak.
4/ 1 inoculated streak each in 1948, 1949, and 1950, 1/3-circum.
5/ 1 " " " " " " " " " , 2/3-circum.
6/ 2 opposite streaks " " " " " " , each 1/3-circum.

Per-Acre Yield of Gum and Wood from Clemson Tract

The Clemson tract contained 85 trees between diameter of 6.5 and 12.9 inches, d.b.h. The mean diameter was 8.9 inches, and the stand was essentially even-aged with a mean age of 45 years. The yield of products after 3 years of working for gum is given below. The gum was collected in conventional Herty cups, the pitch-soaked butt bolts were weighed and analyzed, and the volume of pulpwood remaining was measured.

The following is the actual yield of wood from the 1-acre Clemson stand and the yield of gum, had all 85 trees been given two 1/3-circumference faces per tree, chipped once a year and inoculated:

Exuded gum, 3 years' collection	255 pounds
Scrape gum, at end of third year	39 "
Deposited gum, in 2.08 tons of butt bolts	532 "
Total	826 "
Pulpwood yield - - - - - - - - - - - - - - -	38 cords

Discussion

Although the fungus did induce season-long flow from a single chipping of Virginia pine, and although considerable gum-soaking of the wood took place behind the faces, the yields were too low to make this species attractive at the present time for either turpentining or wood naval stores.

The danger of inducing an epidemic of twig cankering as a result of using the fungus in turpentining has been considered. The work at Clemson was undertaken only when it was confirmed that the pitch-canker disease already occurred naturally, nearby. Several cankers that yielded Fusarium lateritium f. pini upon isolation, were confirmed within a quarter-mile of the study area. When the faces were first inoculated in 1948, a tally of 115 seedling and sapling Virginia pines adjacent to the treated acre disclosed no pitch cankers. Subsequent annual examination of these trees disclosed only one branch pitch-canker during the ensuing 4 years. Thus the use of the fungus on the area seems not to have resulted in an increase in the pitch-canker disease.

The Station's Lake City Center has been working for several years on a selection and breeding program to try to capitalize on high gum-yielding strains of slash pine (1), some of which yielded over twice as much gum as average trees of the same size. One of the most interesting results to come out of this current Virginia pine study was the wide spread in gum yield between the average Virginia pine tree and the occasional high-yielder. For example, at Lenoir 50 trees were all streaked in the same manner, once per year, starting in 1949. Yields, generally, dropped in 1950 as compared with 1949, so that the average yield of 49 of these trees in 1950 was only 11 grams per week. One tree, however, produced an average of 94 grams per week over a 27-week period. This amount, obtained from one pair of fungus streaks (one on each side), is almost as much as an average slash or longleaf pine produces when given 32 untreated streaks per season. If it should be feasible to propagate Virginia pine vegetatively, the fungus method might be used on progeny from trees such as this high-yielder to produce gum very cheaply.

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